

Flow field plates

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Inventor: ROWEN S J (GB); TURPIN M C (GB); ADCOCK R L (GB)

Applicant: LOUGHBOROUGH UNISERSITY INNOVA (GB)

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The present invention relates to flow field plates and the manufacture thereof, for use in fuel cells. The method of manufacture comprises particulate etching of a plate material using a particulate etchant (e.g. sand blasting), a particulate etchant accelerator and a particulate etchant-resistant patterned mask, such that a fluid flow pattern determined by the pattern design on said mask is formed on the plate material.

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Flow field plates**Abstract**

The present invention relates to flow field plates and the manufacture thereof, for use in fuel cells. The method of manufacture comprises particulate etching of a plate material using a particulate etchant (e.g. sand blasting), a particulate etchant accelerator and a particulate etchant-resistant patterned mask, such that a fluid flow pattern determined by the pattern design on said mask is formed on the plate material.

FlowField Plates

This invention relates to flow field plates and the manufacture thereof, for use in fuel cells, electrolyzers, and batteries which contain a fluid electrolyte.

A fuel cell is an electrochemical device in which chemical energy is converted directly into electrical energy. Fuel cells employ electrodes, comprising an anode and a cathode, electrocatalysts, often supported on the electrodes, and an electrolyte. A fuel and an oxidant are separately supplied to the anode and cathode, respectively.

Solid Polymer Fuel cells (SPFC) employ a membrane electrode assembly (MEA), consisting of a solid polymer electrolyte with impressed electrocatalyst layers sandwiched between two electrically conductive plates which have a fluid flow field to distribute the fuel and oxidant across the active area of the electrodes. These flow field plates, also known as current collector plates or bipolar plates, may additionally provide mechanical support for the MEA. Fluid galleries are formed in the faces of the flow field plates to direct fuel and oxidant, respectively, into the fluid flow field. Fluid exit galleries in the flow field plates allow for removal of unreacted fuel and oxidant as well as reaction product (e.g. water in an oxygen/hydrogen fuel cell) formed at the cathode.

Performance of fuel cells is partly dependent on the efficient supply of fuel and oxidant to the electrodes and also the efficient removal of reaction product during functioning of the cell. The design and manufacture of flow fields on flow field plates is thus an important consideration for optimal fuel cell operation.

For most applications, fuel cells may be connected in series to form a "stack" so that voltage output is increased. The flow field plates between cells may be bipolar such that fuel and oxidant are distributed separately through flow fields on opposite faces of the plate. In stacks, flow field plates should be impermeable to reactants to prevent crossover between adjacent cells.

Flow field plates used in fuel cell stacks have been constructed from several types of material. This material requires the following properties:

- (i) chemical compatibility with electrolytes;
- (ii) low resistivity (contact and bulk) to reduce power loss;
- (iii) impermeability to H₂ and O₂;
- (iv) allows for easy manufacture of plates;
- (v) light in weight; and
- (vi) sufficient strength to withstand handling and high compaction pressures.

Carbon-based flow field plates have been reported for use in low temperature fuel cells, particularly SPFCs. Carbon is an excellent material for this application, possessing excellent chemical resistance, low density and high electronic and thermal conductivity.

Press-moulding has been used to fabricate a flow field plate, complete with embossed fluid flow design thereon, from exfoliated graphite. For example, a flow field plate manufactured from a fine grained graphite (GRAFOIL) is provided in US 5 521018.

US 4 301 222 and EP 784 352 describe the use of resins to form plates with improved mechanical strength, but these insulating resins may reduce the overall conductivity of such plates and result in increased losses in fuel cell stacks. In another invention, US 4 339 322, carbon fibres have been added to a polymer/graphite material to

enhance plate strength and conductivity. However, resistivities of the plates disclosed in US 4 339 322 are significantly higher than plate manufactured only from graphite.

As described in US 5 686 199, it is possible to machine fine grained graphite plates to form fluid flow patterns. Due to low mechanical strength of the material, however, these plates are often unacceptably thick. Also, the machining of fluid flow fields on carbon plates is a slow process and tool wear is rapid with this material. Carbon fibre composite materials are even more abrasive and more damaging to cutting tools than standard carbon material. These material have been avoided due to the costly specialised equipment employed.

Current technology therefore does not provide a rapid, low cost process for the manufacture of flow field plates from desirable materials.

The technique of sand, bead, or grit blasting has been described previously for a few specified applications, such as signmaking and decorative patterning on stone, wood, ceramicware, plastic, glass and glass-reinforced plastic (e. g. US 4 828 893 and US 4 985101), and surface cleaning or roughening treatments. Sandblasting has also been employed for forming plasma display apparatus (EP 0 722 179) and in the manufacture of magnetic transducing heads (US 4 188 247).

The present invention provides a novel, effective and improved method for the manufacture of electrochemical cell components such as the flow field plate. The method employs a low cost and rapid erosive etch that allows formation of fluid flow patterns, fluid entry galleries and fluid exit galleries, and scaling grooves.

Thus according to the present invention, there is provided a method for the manufacture of flow field plates comprising particulate etching of plate material using a particulate etchant, a particulate etchant accelerator and a particulate etchant-resistant patterned mask, such that a fluid flow pattern determined by the pattern design on said mask is formed on said plate material.

Plate material for use in the present invention may comprise electrically conductive material. Such electrically conductive material may comprise carbon-based material. Furthermore, plate material may comprise carbon fibre composite material.

This carbon fibre composite material may be densified with a polymeric filler, for example an epoxy resin. It has been found, surprisingly, that the rate of particulate etching of the carbon fibre and matrix in carbon fibre composite material does not differ, so the final structure of patterned grooves formed in this type of materials is not adversely affected.

The particulate etching may comprise sand blasting, and the particulate etchant accelerator may comprise a sandblasting gun. The particulate etching may also comprise grit blasting. Furthermore, the particulate etching may comprise abrasive waterjet blasting (also known as abrasive waterjet cutting). The invention requires that the particulate etchant contains an abrasive medium which has a greater hardness than that of the plate material to be etched. The particulate etchant may be silica grit with a diameter of 180-220, μm for use against plate material which is a graphitised carboncarbon composite material.

The procedure uses a particulate etchant-resistant mask which is patterned accordingly and which covers the face of the material to be etched. The mask may be composed of material that can withstand erosive wear caused by particulate etching. The mask should be in close proximity to the plate material to allow fine detailed patterns to be formed, so the mask may be held in contact with the plate material by means of an adhesive substance.

The particulate etchant-resistant patterned mask may be a photoresist mask.

The technique of forming a photoresist mask is taught in, for example, US 4 764 449.

In US 4 764 499, a negative mask of the required design is formed such that glass or wood exposed after adhesion of the mask is eroded by sandblasting.

The particulate etchant-resistant patterned mask may comprise a vinyl polymer. Here, a vinyl label is cut to shape to form a negative mask of the required pattern (see US 4 828 893).

The pattern design may determine a fluid entry gallery and a fluid exit gallery of the field flow plate. For example, a fluid entry gallery may be a fluid entry hole and a fluid exit gallery may be a fluid exit hole of the flow field plate. Certain etch resists could fail if galleries passing through the plate are etched through one face only. Therefore fluid entry galleries and fluid exit galleries may be formed by etching aligned positions on opposite faces of the flow field plate.

The pattern design may also determine grooves for seals on said flow field plate.

Particulate etching may be under the control of a two-axis scanning mechanism that determines movement of the particulate etchant accelerator relative to the plate material. The two-axis scanning mechanism may enable a predetermined movement of the plate material relative to the particulate etchant accelerator such movement can be in the form of a raster pattern or a stepped scan pattern. A scanning mechanism will be particularly useful when the surface area of the plate material is approaching or greater than the spread of particulate from the particulate etchant accelerator.

Flow field plate manufactured according to the present invention may be incorporated in fuel cells, electrolyzers, and batteries which contain a fluid electrolyte.

An electrolyser, which is a means to decompose water into hydrogen and oxygen, is structurally very similar to a fuel cell.

The invention will be further apparent from the following description, with reference to the several figures of the accompanying drawings, which show, by way of example only, methods for the manufacture of field flow plates comprising different materials.

Of the Figures:

Figure 1 is a schematic side cross-sectional elevation illustrating the particulate etching method employed in the fabrication of fluid flow grooves on a bipolar flow field plate; and

Figure 2 is a schematic side cross-sectional elevation illustrating the particulate etching method employed in the fabrication of a fluid entry or exit hole in a flow field plate.

In Figure 1, a flow field plate 100 prepared for particulate etching comprises the plate material 3, and two opposite faces each layered with an adhesive 2 and 20 upon which the prepared particulate etchant-resistant patterned masks 1 and 10 have been attached. The adhesive 2 and 20 must provide sufficient adhesion to hold the masks 1 and 10 firmly in place during the particulate etching process 6. Preferably, the adhesive 2 and 20 is water soluble so that the masks 1 and 10 can be easily removed from the plate material 3 after etching. The masks 1 and 10 may be mounted on a support film which is peeled away after the masks 1 and 10 have adhered to the adhesive 2 and 20.

Plate material 3 comprises carbon fibre composites, thereby possessing superior mechanical properties to monoliths, without loss of mechanical properties. The inclusion of carbon fibres can improve the thermal conductivity of plate material 3, which is an important feature if the downstream electrical application involves use of high current densities. Fabrication methods for typical carbon-carbon composite material are well known (See Thomas, C. R. [Editor], 1993, *Essentials of carbon-carbon composites*, Cambridge Royal Society of Chemistry Press, Cambridge, ISBN: 0851868045).

Use of high density carbon-carbon composites for plate material 3 is expensive, and partially densified materials may offer greater prospects. The gas permeability of partially densified plate material can be overcome by densification with a polymeric filler such as resin. The resin should preferably be of low viscosity to allow the rapid filling of small pores under low pressure, and should self-cure. The composition of the resin may be of any polymer formulation that will resist attack by an alkaline or acidic electrolyte. Immediately after the addition of a

resin to plate material 3, unabsorbed resin should be removed from the surface of the plate 100. This can be carried out by wiping the plate 100 surface with an absorbent cloth. When the resin has been allowed to cure under the required conditions, surfaces on plate 100 required for electrical conduction need to be cleaned to re-expose conductive carbon in plate material 3. This can be achieved by a brief surface grinding step with an abrasive cloth with a mesh size of 600 or higher.

The particulate etchant-resistant patterned masks 1 and 10 have patterns 4 and 40 through which the plate material 3 will be etched. Pattern 4 on one face of plate material 3 is displaced relative to pattern 40 on the second face of plate material 3 so that a thin sheet of plate material 3 can be employed. Etching process 6 involves the exposure of the plate 100 to a particulate etchant (not shown) which is propelled by a particulate etchant accelerator (not shown) such as a sandblasting gun. The particulate etchant is any material which has a greater hardness than that of the plate material 3 to be etched. For carbonaceous materials (except diamonds), it is preferred that fine grained silica or alumina is used. The etchant size depends on the detail of the patterns 4 and 40 required on the plate 100. The blasting pressure used in process 6 is dependent on masks 1 and 10, the adhesive 2 and 20, the distance between the etchant accelerator and the target surface of the plate material 3, and the etchant used. An upper pressure limit is given by the resistance to erosive etching of the masks 1 and 10, while a lower limit is defined by the pressure required to erode the material 3 with the abrasive etchant.

The blasting pressure is optimal when substantial etching is produced within a reasonable time limit without damaging the masks 1 and 10 or causing the adhesive 2 and 20 to fail.

Etching process 6 is performed in two successive steps in which each face of plate 100 is etched. It is not ruled out, however, that the etching process 6 could be performed on both sides of plate 100 simultaneously using a plurality of particulate etchant accelerators.

During etching process 6, the target area of plate 100 is dependent on the spread of the etchant. This spread, in turn, is dependent on the distance of the particulate etchant accelerator from the surface of plate 100, and the dimensions of the particulate etchant accelerator nozzle (not shown). The plate 100 can be etched in a dynamic manner if the area of plate 100 is larger than the etchant spread. For example, the particulate etchant accelerator and plate 100 can be moved relative to each other using a two-axis scanning mechanism, in which either or both the accelerator and plate 100 are moved. The overall movement should provide uniform coverage of the plate 100 surface with the accelerated etchant.

After completion of etching process 6, the flow field plate 200 has a fluid flow field pattern 5 and 50 etched into the plate material 3 on both sides of the plate 200. The adhesive 2 and 20 and particulate etchant-resistant patterned mask 1 and 10 are then removed.

The fabrication of flow field plate holes for the entry or exit of fluids is illustrated in Figure 2. Preparation of flow field plate 300 requires the alignment of eroding grooves 7 and 70 patterned into the particulate etchant-resistant masks 1 and 10 on opposite faces of the plate material 3. The masks 1 and 10 are held firmly against the plate material 3 using an adhesive 2 and 20. Etching process 60 proceeds until a uniform opening 8 appears from one face of plate 400 through to the opposite face. Etching of both faces of plate material 3 to form the opening 8 is especially important where the material 3 would fail if etched from one face only.

The present invention will be further described by way of the following examples. The scope of the invention, however, is not limited in any way by these examples.

Example 1 (Carbon-carbon composite plate + vinylmask):

A graphitised carbon-carbon composite plate of dimensions 50x50x1.2 mm was prepared with a gas track design on one face. A vinyl-polymer adhesive mask (FasCal Film [Avery, US]), with a negative image of the required gas track design, was pressed firmly onto the composite. A Guyson Blast System (Guyson, UK) with 180-220. μ m silica grit, was used to dry sandblasting the plate. The masked material was held under the sandblasting gun with a

blast pressure set at 4 bar (400 kPa) for 30s, at a constant distance of 6" (152.4 mm). The vinyl mask was then peeled off, and the adhesive washed off the plate using isopropyl alcohol. Track depth was 0.2-0.25 mm.

Example 2 (Carbon-carbon composite plate + photoresist mask):

A graphitised carbon-carbon composite plate of dimensions 50x50x1.2 mm was prepared with a gas track design on one face. A photoresist mask (ImagePro Super

Film [Chromaline Corp., US]) was developed to form a negative template of the required gas track design. Using a photographic mask of the track design to cover the photoresist (with an underside protective carrier film) and a glass sheet to hold the sheets closely together, the film was exposed for 5 minutes to an 18 W UV light source, at a distance of 5 m. The film was then removed (under yellow light) and washed under running water for approximately 3 minutes in order to wash away unexposed resist. The resist film was dried in air, under normal lighting, to form the negative resist mask template. A liquid contact adhesive (ImagePro Adhesive [Chromaline Corp., US]) was brushed lightly over the composite plate surface, and allowed to dry in air for 10 minutes. The resist mask (with carrier film) was pressed onto the adhesive-covered plate, and the carrier film peeled away. The material was then blasted using the procedure described in Example 1 (supra). The resist mask was removed by dissolving the adhesive using warm running water, thus revealing a flow field pattern etched into the carbon-carbon composite material.

Example 3 (Carbon-carbon composite plate with epoxy resin + photoresist mask):

A graphitised carbon-carbon composite plate of dimensions 50x50x1.2 mm was held under low pressure (preferably less than 10 mmHg [approximately 1.33 kPa], but up to 100 mmHg [approximately 13.3 kPa] feasible) impregnated with a low viscosity epoxy resin (SpeciFix-20 [Struers Ltd, UK]). Excess resin was removed from the surface of the plate using a paper towel. The plate was then allowed to stand in air, at standard temperature and pressure, for at least 8 hours to allow the resin to cure and harden. A photoresist mask (ImagePro Super Film) was prepared and then applied as in

Example 2 (supra). The masked material was then blasted using the procedure described in Example 1 (supra). The resist mask was removed by dissolving the adhesive using warm running water.

CLAIMS

1. A method for the manufacture of flow field plates comprising particulate etching of plate material using a particulate etchant, a particulate etchant accelerator and a particulate etchant-resistant patterned mask, such that a fluid flow pattern determined by the pattern design on said mask is formed on said plate material.
2. A method according to claim 1 in which said plate material comprises electrically conductive material.
3. A method according to claims 1 or 2 in which said plate material comprises carbon-based material.
4. A method according to claim 3 in which said plate material comprises carbon fibre composite material.
5. A method according to claim 4 in which said carbon fibre composite material is densified with a polymeric filler.
6. A method according to any of claims 1 to 5 in which said particulate etching comprises sand blasting.
7. A method according to any of claims 1 to 5 in which said particulate etching comprises bead blasting.
8. A method according to any of claims 1 to 5 in which said particulate etching comprises grit blasting.
9. A method according to any of claims 1 to 5 in which said particulate etching comprises abrasive waterjet blasting.
10. A method according to claim 6 in which said particulate etchant accelerator comprises a sandblasting gun.
11. A method according to any of claims 1 to 10 in which said particulate etchant contains an abrasive medium which has a greater hardness than that of said plate material.
12. A method according to claim 11 in which said particulate etchant is silica grit with a diameter of 80-220/m.

13. A method according to claim 12 in which said plate material is a graphitised carbon-carbon composite material.
14. A method according to claim 1 in which said particulate etchant-resistant patterned mask is held in contact with said plate material by means of an adhesive substance.
15. A method according to claim 1 in which said particulate etchant-resistant patterned mask is a photoresist mask.
16. A method according to claim 1 in which said particulate etchant-resistant patterned mask comprises a vinyl polymer.
17. A method according to claim 1 in which said pattern design determines a fluid entry gallery and a fluid exit gallery on said flow field plate.
18. A method according to claim 17 in which said fluid entry gallery and said fluid exit gallery are formed by etching aligned positions on opposite faces of said flow field plate such that said fluid entry gallery and said exit gallery pass through said flow field plate.
19. A method according to claim 1 in which said pattern design determines a sealing groove on said flow field plate.
20. A method according to claim 1, in which said particulate etching is under control of a two-axis scanning mechanism that determines movement of said particulate etchant accelerator relative to said plate material.
21. A method according to claim 20, in which said two-axis scanning mechanism enables a predetermined movement of said plate material relative to said particulate etchant accelerator such that said movement is in the form of a raster pattern or a stepped scan pattern.
22. A product obtained using a method according to any one of claims 1-21.

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[71] 申请人 拉夫伯勒大学革新有限公司

地址 英国拉夫伯勒

[72] 发明人 S·J·罗文 M·C·图尔平

P·L·阿德科克

D·戴维斯

[74] 专利代理机构 中国专利代理(香港)有限公司

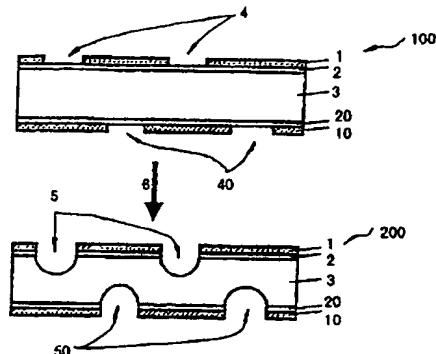
代理人 罗 朋 张志醒

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[54] 发明名称 流场板

[57] 摘要

本发明涉及用于燃料电池的流场板及其制备方法。制备方法包括利用颗粒蚀刻剂(例如砂磨)、颗粒蚀刻加速器和耐颗粒蚀刻构图掩模对板材料进行颗粒蚀刻,从而在板材料上形成由所述掩模上的图案设计所确定的流体流动图案。



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权 利 要 求 书

1、流场板的制备方法，包括：利用颗粒蚀刻剂、颗粒蚀刻加速器和耐颗粒蚀刻构图掩模对板材料进行颗粒蚀刻，从而在所述板材料上形成由所述掩模上的图案设计所确定的流体流动图案。

5 2、按照权利要求 1 的方法，其中所述板材料包括导电材料。

3、按照权利要求 1 或 2 的方法，其中所述板材料包括碳基材料。

4、按照权利要求 3 的方法，其中所述板材料包括碳纤维复合材料。

5、按照权利要求 4 的方法，其中所述碳纤维复合材料用聚合物填料来使其致密。

10 6、按照权利要求 1-5 的任一个的方法，其中所述颗粒蚀刻包括砂磨。

7、按照权利要求 1-5 的任一个的方法，其中所述颗粒蚀刻包括珠磨。

8、按照权利要求 1-5 的任一个的方法，其中所述颗粒蚀刻包括喷砂。

15 9、按照权利要求 1-5 的任一个的方法，其中所述颗粒蚀刻包括磨料水射喷砂。

10、按照权利要求 6 的方法，其中所述颗粒蚀刻加速器包括喷砂枪。

20 11、按照权利要求 1-10 的任一个的方法，其中所述颗粒蚀刻剂包含硬度大于所述板材料的磨料介质。

12、按照权利要求 11 的方法，其中所述颗粒蚀刻剂是直径为 180-220 μm 的硅砂。

25 13、按照权利要求 12 的方法，其中所述板材料是石墨化碳-碳复合材料。

14、按照权利要求 1 的方法，其中所述耐颗粒蚀刻构图掩模通过粘合剂物质与所述板材料保持接触。

15、按照权利要求 1 的方法，其中所述耐颗粒蚀刻构图掩模是光致抗蚀剂掩模。

30 16、按照权利要求 1 的方法，其中所述耐颗粒蚀刻构图掩模包括乙烯基聚合物。

17、按照权利要求 1 的方法，其中所述图案设计确定所述流场板上

的流体进入孔道和流体排出孔道。

18、按照权利要求 17 的方法，其中通过蚀刻在所述流场板的相对表面上对准的位置，形成所述流体进入孔道和所述流体排出孔道，从而使所述流体进入孔道和所述流体排出孔道通过所述流场板。

5 19、按照权利要求 1 的方法，其中所述图案设计确定所述流场板上的密封凹槽。

20、按照权利要求 1 的方法，其中所述颗粒蚀刻受二轴扫描机械的控制，其确定所述颗粒蚀刻加速器相对于所述板材料的运动。

10 21、按照权利要求 20 的方法，其中所述二轴扫描机械能使所述板材料相对于所述颗粒蚀刻加速器进行预定运动，使所述运动形式是光栅图案或步进扫描图案。

22、利用按照权利要求 1-21 的任一个的方法所得到的产品。

说 明 书

流场板

本发明涉及用于包含流体电解质的燃料电池、电解槽和电池的流场板及其制备。
5

燃料电池是把化学能直接转变成电能的电化学装置。燃料电池采用包括阳极和阴极的电极、常支撑在电极上的电催化剂以及电解质。燃料和氧化剂分别供给阳极和阴极。

10 固体聚合物燃料电池 (SPFC) 采用薄膜电极组件 (MEA)，由具有外加的电催化剂层的固体聚合物电解质组成，该电催化剂层夹在两个导电板之间，导电板具有穿过电极活性区分布燃料和氧化剂的流体流场。这些流场板也公知为集电板或双极板，可为 MEA 额外提供机械支撑。流体孔道形成在流场板表面上，以引导燃料和氧化剂分别流向流体流场。流场板中的流体排除孔道能够清除未反应的燃料和氧化剂 15 以及在阴极形成的反应产物（例如氧/氢燃料电池中的水）。

燃料电池的性能部分取决于把燃料和氧化剂有效供给电极以及电池运行期间反应产物的有效清除。因此，流场板上的流场设计和制备是燃料电池最佳运行的重要条件。

20 对于大多数应用，燃料电池可串联连接，形成“叠层”，从而提高电压输出。电池之间的流场板可以是双极性，从而在板的相对表面上经流场分别分布燃料和氧化剂。在叠层中，流场板应不能透过反应物，以防止相邻电池之间的干扰。

用于燃料电池叠层中的流场板由多种材料组成。该材料需要如下性能：
25

- i) 与电解质的化学相容性；
- ii) 低电阻率（接触电阻和体电阻），以便降低能量损耗；
- iii) 不能透过 H_2 和 O_2 ；
- iv) 板容易制备；
- v) 重量轻；和
- vi) 有足够强度，可承受加工和高冲压。

30 有报道碳基流场板用于低温燃料电池特别是 SPFC。碳是该应用的优良材料，具有优良的化学耐性、低密度和高的导电以及导热性。

利用模压，用片状石墨来制备流场板，其上凸起流体流动结构。例如，US5521018 提供了细粒石墨 (GRAFOIL®) 制备的流场板。

US4301222 和 EP784352 描述了应用树脂以形成板，机械强度得到改善，但这些绝缘树脂会降低板的整体导电率，导致燃料电池叠层的损耗增大。在另一发明中，碳纤维已加入到聚合物/石墨材料中，提高板强度和导电率。然而，US4339322 所公开的板的电阻系数远远高于只由石墨制备的板。

如 US5686199 所述，可加工细粒石墨板，形成流体流动图案。然而，由于该材料的机械强度低，这些板厚得令人难于接受。同时，在 10 碳板上加工流体流场是个慢工序，该材料对工具磨损快。与标准碳材料相比，碳纤维复合材料更耐磨，更易损伤切割工具。由于采用高价的专业设备，应避免这些材料。

因此，对于由理想材料制备流场板，目前的技术尚不能提供快速、低成本的工艺。

对于一些特定应用，以前描述过砂磨、珠磨或喷砂，例如在石头、木头、陶瓷品、塑料、玻璃和玻璃加强塑料上作记号和装饰图案（例如 US4 828 893 和 US4 985 101）以及表面清洁或弄糙处理。也已采用砂磨来形成等离子体显示装置 (EP0 722 179) 和制备磁转换头 (US4 188 247)。

本发明提供制备电化学电池元件例如流场板的新颖、有效和改进的方法。该方法采用低成本、快速的侵蚀蚀刻，能形成流体流动图案、流体进入孔道和流体排出孔道以及密封凹槽。

因此，按照本发明，提供了流场板的制备方法，包括：利用颗粒蚀刻剂、颗粒蚀刻加速器和耐颗粒蚀刻剂图案掩模对板材料进行颗粒蚀刻，从而由所述掩模上的图案设计确定的流体流动图案形成在所述板材料上。

用于本发明的板材料可包括导电材料。该导电材料可包括碳基材料。此外，板材料可包括碳纤维复合材料。该碳纤维复合材料可用聚合物填料例如环氧树脂使其致密。惊奇地发现，碳纤维复合材料中的碳纤维和基质的颗粒蚀刻速率相同，从而未对形成在这种材料中的构图凹槽的最终结构产生不利影响。

颗粒蚀刻包括砂磨，颗粒蚀刻加速器可包括砂磨枪。颗粒蚀刻也

可包括喷砂。此外，颗粒蚀刻可包括磨料水射喷砂（也称为磨料水射切割）。本发明需要颗粒蚀刻剂包含磨料介质，它比要蚀刻的板材料具有更大硬度。颗粒蚀刻剂可以是直径 180-220 μm 的硅石砂，用于蚀刻石墨化碳-碳复合材料的板材料。

5 本工艺使用了耐颗粒蚀刻剂掩模，掩模被适当构图并覆盖要蚀刻的材料表面。掩模可以由能承受颗粒蚀刻所引起的侵蚀磨损的材料组成。掩模应紧靠近板材料，以便能形成精细图案，从而通过粘合物质可将掩模与板材料保持接触。

耐颗粒蚀刻剂构图掩模可以是光致抗蚀剂掩模。在例如
10 US4764449 中公开了形成光致抗蚀剂掩模的技术。US4764499 中，形成所需设计的负掩模，从而粘附掩模之后利用砂磨侵蚀暴露的玻璃或木头。

耐颗粒蚀刻剂构图掩模可包括乙烯基聚合物。在此，切割乙烯基标签以成形，形成所需图案的负掩模（参见 US4828893）。

15 图案设计可确定流场板的流体进入孔道和流体排出孔道。例如，流体进入孔道可以是流体入口，而流体排出孔道可以是流场板的流体出口。如果只经一个表面蚀刻通过板的孔道，某些耐蚀剂会失效。因此，流体进入孔道和流体排出孔道可通过蚀刻流场板的相对表面上的对准位置而形成。

20 图案设计也可确定所述流场板上用于密封的凹槽。

颗粒蚀刻可受二轴扫描机械控制，二轴扫描机械确定颗粒蚀刻加速器相对板材料的运动。二轴扫描机械能使板材料相对于颗粒蚀刻加速器预定运动，运动的形式可以是光栅图案或步进扫描图案。当板材料的表面面积接近或大于颗粒蚀刻加速器的颗粒扩散时，扫描机械特别有用。

25 按照本发明制备的流场板可引入在包含流体电解质的燃料电池、电解槽和电池中。电解槽是将水分解成氢和氧的装置，其结构类似于燃料电池。

参考附图，利用如下描述可进一步清楚本发明，仅通过例子表示
30 包括不同材料的流场板的制备方法。

附图：

图 1 是说明在双极流场板上制备流体流动凹槽所用颗粒蚀刻方法

的示意侧剖视图；和

图 2 是说明在流场板上制备流体流体入口或出口所用颗粒蚀刻方法的示意侧剖视图，。

图 1 中，颗粒蚀刻制备的流场板 100 包括板材料 3 和两个相对表面，5 每个表面层压有所制备的耐颗粒蚀刻构图掩模 1 和 10 已粘附其上的粘合剂 2 和 20。粘合剂 2 和 20 必须提供足够的粘合力，以便在颗粒蚀刻工艺 6 期间牢固保持掩模 1 和 10 就位。优选粘合剂 2 和 20 是水溶性的，从而在蚀刻之后掩模 1 和 10 可容易从板材料 3 清除。掩模 1 和 10 可放置在支撑膜上，在掩模 1 和 10 已粘附到粘合剂 20 上之后，10 剥离支撑膜。

板材料 3 包括碳纤维复合物，从而整体具有优良机械性能，而不损失机械性能。掺杂碳纤维可改善板材料 3 的导热性，如果下游电应用包括高电流密度的使用，导热性是一个重要特征。典型的碳-碳复合材料的制备方法已公知(参见 Thomas, C.R. [Editor], 1993, *Essentials of carbon-carbon composites*, Cambridge Royal Society of Chemistry Press, Cambridge, ISBN: 0851868045)。

用于板材料 3 的高密度碳-碳复合材料昂贵，部分致密的材料可提供更大的前景。利用聚合物填料例如环氧树脂使其致密可克服部分致密板材料的透气性。优选树脂是低粘度，低压下能快速填充细孔并能自固化。树脂构成可以是耐碱性或酸性电解质的任何聚合物。在树脂加入到板材料 3 之后，未吸收的树脂应立刻从板 100 的表面上清除。这可通过吸收布擦洗板 100 来完成。当树脂在所需的条件下已固化时，板 100 上需要导电的表面需要清洁，以便重新曝露板材料 3 的导电碳。利用筛目大小为 600 或更高的砂布进行简单表面研磨就可完成。

25 耐颗粒蚀刻构图掩模 1 和 10 具有经此蚀刻板材料 3 的图案 4 和 40。在板材料 3 的一个表面上的图案 4 相对于板材料 3 的第二表面上的图案 40 移位，从而可采用薄片板材料 3。蚀刻工艺 6 包括使板 100 曝露给颗粒蚀刻剂(未示出)，用颗粒蚀刻加速器(未示出)例如喷砂枪推动颗粒蚀刻剂。颗粒蚀刻剂是硬度高于将要蚀刻的板材料 3 的任何材料。对于碳素材料(除金刚石之外)，优选使用细粒硅砂或铝砂。蚀刻剂大小取决于板 100 上所需的图案 4 和 40 的细节。

30 工艺 6 所采用的喷砂压力取决于掩模 1 和 10、粘合剂 2 和 20、蚀

刻加速器与板材料 3 的目标表面之间的距离以及所用的蚀刻剂。压力上限由掩模 1、10 的耐侵蚀蚀刻性给定，而压力下限由磨料蚀刻剂侵蚀材料 3 所需的压力确定。当在适当时限内可实现基本蚀刻而不损伤掩模 1 和 10 或导致粘合剂 2 和 20 失效时的喷砂压力为最佳。

5 在蚀刻板 100 的每个表面的两个连续步骤中进行蚀刻工艺 6。然而，并未排除使用多个颗粒蚀刻加速器同时在板 100 的两面上进行蚀刻工艺 6。

10 蚀刻工艺 6 期间，板 100 的目标区域取决于蚀刻剂的分布。该分布又取决于颗粒蚀刻加速器与板 100 表面的距离以及颗粒蚀刻加速器喷嘴（未示出）的大小。如果板 100 的区域大于蚀刻剂分布，可以用动态方式蚀刻板 100。例如，利用二轴扫描机械，使颗粒蚀刻加速器和板 100 相互相对移动，其中移动加速器和板 100 两个或其中任一个。整个移动应使加速蚀刻剂均匀覆盖板 100 的表面。

15 完成蚀刻工艺 6 之后，流场板 200 在板 200 的两面上具有对板材料 3 蚀刻的流体流场图案 5 和 50。然后清除粘合剂 2 和 20 以及耐颗粒蚀刻构图掩模 1 和 10。

20 用于流体入口或出口的流场板孔道的制备在图 2 示出。制备流场板 300 要求在板材料 3 的相对表面上使已构图成耐颗粒蚀刻掩模 1 和 10 的侵蚀凹槽 7 和 70 对准。利用粘合剂 2 和 20 使掩模 1 和 10 牢固保持在板材料 3 上。继续蚀刻工艺 60 直至均匀开口 8 从板 400 的一个表面通向相对表面。蚀刻板材料 3 的两面以便形成开口 8 特别重要，如果只从一个表面蚀刻，材料 3 会失效。

通过如下例子，将进一步描述本发明。然而，本发明的范围无论如何不受这些例子限定。

25 例子 1 (碳-碳复合板+ 乙烯基掩模)

在一个表面上用气体径迹设计制备尺寸 $50 \times 50 \times 1.2\text{mm}$ 的石墨化碳-碳复合板。利用所需的气体径迹设计的负图象，将乙烯基聚合物粘合剂掩模 (FasCal Film [Avery, US]) 牢固压在复合物上。使用 180-220 μm 硅砂的 Guyson Blast System (Guyson, UK) 来干砂磨该板。喷砂压力设定为 4bar (400kPa)，在恒定距离 6' (152.4mm) 下，被掩模过的材料在喷砂枪下保持 30S。然后剥离乙烯基掩模，利用异丙醇清洗掉板上的粘合剂。径迹深度为 0.2-0.25mm。

例子 2 (碳-碳复合板+光致抗蚀剂掩模)

在一个表面上用气体径迹设计制备尺寸 $50 \times 50 \times 1.2\text{mm}$ 的石墨化碳-碳复合板。对光致抗蚀剂掩模 (ImagePro Super Film [Chromaline Corp., US]) 显影，形成所需的气体径迹设计的负样板。利用径迹设计的照相掩模来覆盖光致抗蚀剂 (具有下侧保护载体膜) 和玻璃板，以将这些板紧密保持在一起，在 5m 的距离下将膜曝光在 18W UV 光源下 5 分钟。然后为洗去未曝光的抗蚀剂，在流水下清除 (黄光下) 和清洗该膜约 3 分钟。在普通光下空气中干燥抗蚀剂膜，形成负抗蚀剂掩模样板。在复合板表面上轻轻刷上液体压合式粘合剂 (ImagePro Adhesive [Chromaline Corp., US])，空气中干燥 10 分钟。在粘合剂覆盖的板上压上抗蚀剂 (具有载体膜)，剥离载体膜。然后利用例子 1 (上述) 所述的工艺对材料喷砂。利用流动温水溶解粘合剂，清除抗蚀剂掩模，从而展现了对碳-碳复合材料蚀刻的流场图案。

例子 3 (具有环氧树脂的碳-碳复合板+光致抗蚀剂掩模)

在浸渍有低粘度环氧树脂 (SpeciFix-20 [Strers Ltd, UK]) 的低压 (优选适宜压力小于 10mmHg [约 1.33kPa]，但直至 100mmHg [约 13.3kPa] 是可行的) 下，保持尺寸 $50 \times 50 \times 1.2\text{mm}$ 的石墨化碳-碳复合板。利用纸巾从板表面上清除过量的树脂。然后在标准温度和压力下，将板在空气中存放至少 8 小时，以便使树脂固化和硬化。制备光致抗蚀剂掩模 (ImagePro Super Film)，然后按例子 2 (上述) 那样应用。然后利用例子 1 (上述) 所述工艺对被掩模的材料喷砂。利用流动温水溶解粘合剂，清除抗蚀剂掩模。

说 明 书 附 图

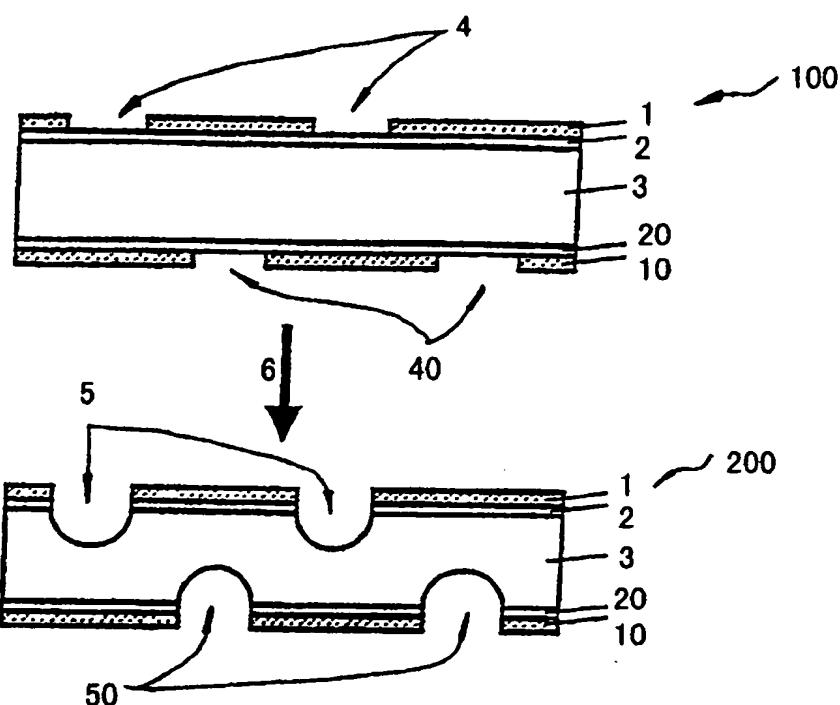


图 1

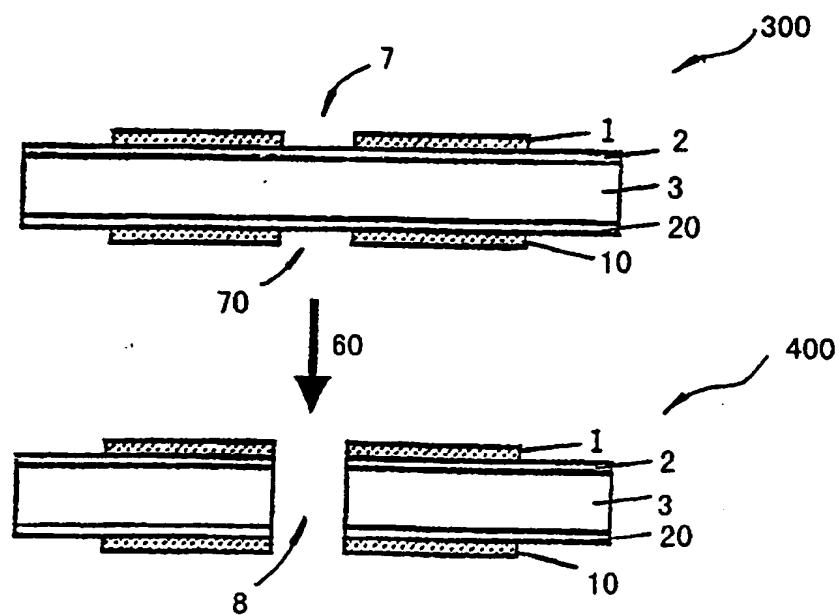


图 2